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Lofgren, SE; Wiener, P; Blott, SC; Sanchez-Molano, E; Woolliams, JA; Clements, DN; Haskell, MJ

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1 **Management and Personality in Labrador Retriever dogs**

2

3 Sarah E. Lofgren¹, Pamela Wiener², Sarah C. Blott³, Enrique Sanchez-Molano², John A.

4 Woolliams², Dylan N. Clements^{1,2}, Marie J. Haskell⁴

5

6 1. Royal (Dick) School of Veterinary Science, University of Edinburgh, Easter Bush,

7 Scotland, UK

8 2. Roslin Institute, Royal (Dick) School of Veterinary Science, University of Edinburgh,

9 Easter Bush, Scotland, UK

10 3. Animal Health Trust, Newmarket, UK

11 4. Scotland's Rural College, West Mains Road, Edinburgh, Scotland, UK

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Abstract

Canine personality is of keen interest to dog owners and researchers alike. The regular human contact with them makes dogs an ideal species to use in the investigation of animal personality. This study specifically focused on Labrador Retrievers, consistently one of the most popular breeds both in the UK and around the world. Using surveys completed by dog owners, data was gathered on the behaviour of the dogs, in addition to the physical characteristics and management characteristics of the dogs (n=1978). Twelve personality traits were identified and investigated for associations with the demographic data. It was found that the working status of the dog was more commonly associated with differences in personality than other analyzed factors. Gundogs had higher scores for ‘fetching tendency’ and ‘trainability’ than Showdogs or Pets ($P<0.05$). Chocolate dogs were more ‘agitated when ignored’ and showed more ‘excitability’ than black dogs, and lower ‘trainability’ and ‘noise fear’ than both yellow and black dogs (all $P<0.05$). Dogs exercised for longer periods showed less aggression, less fear of humans and objects and lower separation anxiety than dogs that were not as active. The effects observed in this study may be due to the experience and training of the dogs, the work-related genetic strain of Labrador Retriever or most likely, a combination of both influences.

Keywords: Labrador Retriever, Management, Personality, Demographics, C-BARQ, canine

35 **1. Introduction**

36 It is commonly observed that individual animals show consistency in the way they
37 respond to situations, and that the intensity of the response varies between individuals. In
38 farm animals this phenomenon is termed temperament (Burrow and Corbet, 2000, Hoppe *et*
39 *al.*, 2010). However, in dogs it is often called personality (Svartberg *et al.* 2005, Ley *et al.*,
40 2008), and this is the convention that we will follow for this paper.

41 An animal's personality arises from the influences of both genetics and its
42 environment, including previous experience. Prenatal experience has been shown to have
43 long term effects on personality and other traits. Zebra finch eggs injected with testosterone
44 produced birds that habituated quicker to novel food (Tobler and Sandell, 2007). Sows born
45 to mothers that experienced social stress during pregnancy show more restlessness and
46 aggression toward their own piglets (Jarvis, *et al.*, 2006). There are also many postnatal
47 influences that determine an animal's personality. Critical periods in early life are known to
48 affect the long-term behaviour of the dog (Scott and Marston, 1950). The time at which a
49 puppy is introduced to humans is critical, with earlier introduction resulting in more
50 positive reactions towards humans in adulthood (Freedman *et al.*, 1961). Svartberg *et al.*
51 (2005) also found that dogs' reactions to some tests changed following later repetition, such
52 as tests intended to provoke aggression using unusual stimuli. Although the individual dogs'
53 reactions changed, the relative ranking of the dogs remained the same. Since personality is
54 unique to each individual animal, it can be influenced by other factors and experiences in
55 the animals' life history. Kutsumi *et al.*, (2013) found that puppy training classes improved
56 long term obedience as well as response to strangers. McMillan *et al.*, (2013) found that
57 puppies obtained from pet stores scored less favorably on a personality assessment than

58 puppies from non-commercial breeders, such that pet store dogs showed higher aggression
59 and separation-related problems than dogs purchased from breeders. Later retesting
60 produced similar results, showing that early experience has a long-term effect on the
61 personality of the dogs.

62 The genetic influence on animal personality has often been studied in terms of breed
63 differences. Differences in temperament were found between breeds of cattle which were
64 raised in identical environments (Hoppe *et al.*, 2010). These differences are presumably due
65 to genetic differences, since other variation had been removed. Dog breeds are well known
66 to show differences in personality (Hart and Hart, 1995). Dachshunds and Chihuahuas have
67 shown higher aggression toward humans, while Akitas and Pit Bull Terriers show higher
68 dog-directed aggression (Duffy *et al.*, 2008). Personality traits, including aggression, have
69 also been shown to be heritable in dogs in a number of studies (Liinamo *et al.*, 2007;
70 Mackenzie, *et al.*, 1986; Goddard and Beilharz, 1983; Sætre *et al.*, 2006), which could
71 have implications for breeding programmes. This is especially true for working dogs, since
72 an appropriate personality is important to fulfilling their duties. Additionally, Svartberg *et*
73 *al.*, (2006) found that recent selection pressures have affected personality, with personality
74 being more highly correlated with the current role of the dogs than with the breed's original
75 purpose. For instance, breeds that are currently popular as house pets show higher
76 playfulness regardless of the breeds' original purpose. The same experience is likely to
77 affect genetically different individuals in different ways (Stamps and Groothuis, 2010).

78 As personality traits have been shown to be influenced by both genetic and non-
79 genetic ('environmental') factors, it is of interest to determine the relative importance of
80 these different factors. In this case, 'environment' is defined as the management and

81 housing conditions experienced by domestic dogs. 'Physical' traits, such as age, sex and
82 bodyweight, are also likely to influence personality. Therefore the aim of this study was to
83 determine how personality traits are affected by physical and management factors in dogs.
84 In order to account for the complexity of the study a large sample size was needed. In order
85 to accomplish this, surveys were sent to several thousand dog owners. The Canine
86 Behaviour and Research Questionnaire (C-BARQ), developed at the University of
87 Pennsylvania, was used for this study (<http://vetapps.vet.upenn.edu/cbarq/>). Originally
88 developed as a method for evaluating and predicting the success of guide dogs (Serpell and
89 Hsu, 2001), this survey can be filled out by any dog owner. It covers many behavioural
90 responses which are categorized into different aspects of animal personality. The survey
91 responses are recorded on a 1 to 5 scale of the intensity of behavioural response to various
92 situations. This is very similar to the approach of Svartberg and Forkman (2002), except the
93 ratings are made by owners instead of a separate observer, and the behaviours recorded are
94 elicited by normal interactions instead of induced by the test setup. The C-BARQ has been
95 translated and used successfully in Japan (Nagasawa, *et al.*, 2011), Taiwan (Hsu and Sun,
96 2010), and the Netherlands (van den Berg *et al.*, 2006), further demonstrating its generality.
97 It has been used in the past to identify problematic behaviours being exhibited by individual
98 dogs (Hsu and Serpell, 2003). It has also been used to study variation in specific traits
99 among dogs. Using the C-BARQ, Duffy *et al.*, (2008) found that levels of aggression
100 towards people versus aggression towards dogs varies within and between breeds.

101 For this study the issue of between-breed variation was eliminated by only studying
102 a single breed, Labrador Retrievers registered with the UK Kennel Club. The overall aim of

103 the study was to test for associations between the animal's physical characteristics,
104 lifestyle, potential genetic differences, and personality.

105

106 **2. Materials and Methods**

107 **2.1. Surveys**

108 A survey was created to gather demographic and management data on the dogs
109 participating in a larger study investigating the factors associated with canine hip dysplasia.
110 It included 38 questions on physical traits such as weight, coat colour and health, as well as
111 management data related to activities, housing, management and feeding (further details
112 given below).

113 The C-BARQ questionnaire consists of 102 questions pertaining to dog behaviour,
114 divided into seven sections. The sections pertain to Training and obedience (8 questions),
115 Aggression (25), Fear and anxiety (19), Separation-related behaviour (8), Excitability (6),
116 Attachment and attention seeking (6), and Miscellaneous (Barking, chasing, unusual
117 behaviours, etc.) (28).

118 The demographic survey was sent by the UK Kennel Club to the owners of 12,408
119 registered Labrador Retrievers which had known hip scores. Of these, 3071 surveys were
120 completed and returned. The Canine Behavioural Assessment and Research Questionnaire
121 (C-BARQ) surveys were distributed to the 2974 of those who had completed the first
122 survey and also agreed to take part in the personality assessment. C-BARQ surveys were
123 received for 2020 dogs.

124

125 **2.2. Personality trait analysis**

126 C-BARQ responses were recorded as letters A-E, with A representing a low or
127 infrequent display of the behaviour in question, and E representing a high or frequent
128 response. The C-BARQ data was transformed to numerical values, with A=1, B=2, C=3,
129 D=4, E=5, and non-responses (N/A or Unanswered). Histograms were plotted for each
130 question which were used to examine response variation for each question. Values for
131 questions 6-8 (regarding disobedience) were reversed so 'desirable' was represented by a
132 high score and 'undesirable' by a low score to be consistent with the other questions in that
133 section. A description of the seven categories of behaviour are shown in Table 1.

134 In order to define distinct personality traits, we investigated whether some of the
135 questions referred to the same or closely related behavioural characteristics. A Principle
136 Components Analysis (PCA) for correlation was run in Minitab 16 (Minitab Inc.) to
137 determine whether the answers to individual questions related to each other. Questions with
138 100 or more missing values were removed from analysis. This included questions 23, 32-
139 36, 42, 50, 66, 71, 79, 87, and 103. These questions largely concerned multi-dog
140 households or other situations that many owners and dogs had never been exposed to.
141 Surveys missing any responses from the remaining questions were removed due to the
142 constraints of the PCA. This resulted in a final sample size of 1077 surveys covering 89
143 questions. The first three components of the PCA accounted for 13%, 6.6%, and 3.9% of
144 the variation, respectively. On the basis of the clustering of the question level traits (Figure
145 1), they were combined into 'personality traits' by taking the mean of the responses to
146 questions within each PCA-defined group of traits, with the added constraint that the
147 questions were from the same category in the C-BARQ questionnaire (Hsu & Serpell,
148 2003; <http://vetapps.vet.upenn.edu/cbarq/>). For example, the trait of Owner aggression was

149 calculated by averaging the values of all the questions that pertained to aggressive
150 behaviour directed at the owner of the dog (Questions 10,14,15,18,20,26,31).
151 Urinating/defecating was removed due to very low variation (all dogs had low scores). The
152 correlations between the 18 remaining personality traits (Supplementary Table 1) were then
153 calculated with the aim of further combining highly correlated traits (>0.4), again with the
154 constraint that the questions were from the same category in the questionnaire
155 (Supplementary Table 2). All questions included in the highly correlated traits were
156 averaged to create the new trait in the same process as described above. If a survey had
157 missing values for more than half the questions used to make up a personality trait, that
158 individual did not receive a value for that trait.

159 This analysis resulted in a final group of 12 personality traits: Agitated when
160 Ignored, Attention Seeking, Barking Tendency, Excitability, Fetching, Human and Object
161 Fear, Noise Fear, Non-Owner Aggression, Owner Aggression, Separation Anxiety,
162 Trainability, and Unusual Behaviour (Supplementary Table 3).

163

164 **2.3. Management/Physical Traits**

165 Following a quality control procedure to remove questionnaires missing key data,
166 complete C-BARQ surveys and management and physical characteristics data were
167 available for 1978 dogs. Age at the time of survey completion was calculated from the date
168 of birth and the survey received date. Age was then rounded to the nearest 0.5 years. Dogs
169 were aged between 2 and 9.5 years. Measurements made in Imperial units were converted
170 to SI units. Body mass index (BMI) was calculated as Girth divided by Length squared.
171 Dogs were separated into categories based on their Working Status. These categories were

172 Pets, Gundogs, and Showdogs. Dogs that were reported as ‘Other’ were either reassigned
173 based on information provided in the comments or removed, resulting in a final sample size
174 of 1,978. Dogs that were reported as being both Pets and Gundogs were classified as
175 Gundogs, while dogs classified as Showdogs and Pets were grouped with Showdogs. Dogs
176 were classified as living Indoor, Outdoor, or Indoor/Outdoor based on where they were
177 reported to spend most of their time throughout the year. For instance, if a dog spent most
178 of its time in a run, outdoor kennel, or yard, it was classified as Outdoor. If it spent most of
179 its time in a house or garage, it was classified as Indoor. Dogs that were classified as Indoor
180 for one half of the year and Outdoor for the other comprise the Indoor/Outdoor category.
181 Gender Status was used to combine the Gender and Neuter responses. This resulted in four
182 possible categories: Entire Males (EM) for uncastrated dogs, Entire Females (EF) for
183 unneutered bitches, Neutered Males (NM) for castrated dogs, and Neutered Females (NF)
184 for neutered bitches. Coat Colour was limited to the three main colours of Black,
185 Chocolate, and Yellow. The small number of dogs that reported a coat colour of Fox Red
186 (5), Liver (17), or Black and Tan (2) were grouped with the three categories Yellow,
187 Chocolate, and Black, respectively. Health Status was determined by the presence of a
188 disease or veterinary condition, with dogs either identifying as healthy (0) or having a
189 significant health problem (1). No single health problem occurred with high enough
190 frequency to be examined independently. Exercise was categorized into 1 (up to one hour
191 per day), 2 (1-2 hours), 3 (2-4 hours), or 4 (more than 4 hours).

192 Sire ID was used to identify full or half siblings and was used to account for any
193 variation due to family relationships. Of the study dogs, 693 had sires which had no other
194 progeny in our study. The remaining 1285 dogs had sires that had between 2 and 37

195 progeny in our sample (mean family size=1.91, median=1). In summary, eight factors were
196 extracted from the demographic survey for use in subsequent analysis: Age, BMI, Coat
197 Colour, Gender Status, Health Status, Indoor/Outdoor Housing, Exercise, and Working
198 Status.

199

200 **2.4. Statistical model-building**

201 Models were analyzed in Genstat 15 (VSN International, 2000-2013) using the
202 General Linear Mixed Models option with Sire Identity as the random term. The binomial
203 variable of Health Status was analyzed using a Binomial model with a binomial total of 2
204 and a Logit link function. Variables that had a normal distribution were analyzed using a
205 Normal model with an Identity link function. Variables where the distribution of responses
206 was right-skewed were analyzed using a Poisson model with a Logarithm link function.
207 The single variable where the distribution was left-skewed (Fetching) was a single-question
208 personality trait and was therefore analyzed using a Binomial model with a binomial total
209 of 5 and a Logit link function.

210

211 For constructing the models we followed a set of rules designed to determine the
212 explanatory variables that influenced each of the twelve response variables. The eight
213 explanatory variables were all included in the model together. The variables with the
214 highest p-values were then removed singly until all variables in the model had p-values \leq
215 0.200

216

217 **2.4.1. Interactions**

218 All two-way interactions between the demographic factors were checked by
219 including only the two independent variables and the interaction between them in the
220 model. Only interactions which returned a p-value of 0.05 or lower during this analysis
221 were included in the next step. These interactions were added simultaneously to the
222 previously established model of demographic factors. Those with the highest p-values were
223 removed until all interactions in the model had a p-value ≤ 0.05 , leading to the final model.

224 Effect size was determined by taking the largest difference between means for a
225 single factor in the final model, e.g. the difference between Chocolate and Black dogs for
226 Agitated when Ignored. Average effect size is the mean of all significant effects within a
227 factor.

228

229 **3. Results**

230 A different full model was used for each response variable. Variables included in
231 the models and their significance are shown in Table 2; interactions present in the model
232 are shown in Table 3, and effect sizes are shown in Table 4.

233

234 **3.1. Working Status**

235 The factor significantly associated with the most response variables was the
236 Working Status of the dogs (Figure 2). Working Status featured in all models except
237 Separation Anxiety, and was significantly associated with all response variables except
238 Separation Anxiety and Owner Aggression. There was an average effect size of 0.33 over
239 all significant associations, the highest of all factors. Pets and Gundogs were more Agitated
240 when Ignored than Showdogs. Gundogs exhibited more Attention Seeking than Showdogs

241 and Pets. Pets showed greater Barking Tendency and Excitability than Gundogs. Gundogs
242 showed higher Fetching Tendency than Showdogs or Pets, and this factor had the largest
243 effect size (1.32). Pets and Gundogs exhibited more Human and Object Fear than
244 Showdogs. Pets showed greater Noise Fear than Gundogs or Showdogs. Pets showed more
245 Non-Owner Aggression than Showdogs. Gundogs exhibited greater Trainability than Pets,
246 and both were greater than Showdogs. Finally, Showdogs and Pets were more likely to
247 exhibit Unusual Behaviours than Gundogs.

248

249 **3.2. Coat Colour**

250 Coat Colour was also shown to be associated with several response variables, and
251 had an average effect size of 0.19. Chocolate dogs were more Agitated when Ignored than
252 Black dogs. Chocolate dogs showed more Excitability than Black dogs. Black dogs showed
253 a higher Fetching Tendency than Chocolate dogs. Black and Yellow dogs showed higher
254 Noise Fear than Chocolate. Yellow dogs showed more Separation Anxiety than Black dogs.
255 Chocolate dogs exhibited lower Trainability and a higher incidence of Unusual Behaviour
256 than Black or Yellow dogs.

257

258 **3.3. Exercise**

259 The amount dogs were exercised was significantly associated with several
260 personality traits and had the third highest average effect size (0.17). Dogs exercised <1
261 hour/day were more likely to become Agitated when Ignored than dogs exercised 1-4
262 hours/day. Dogs exercised <1 hour/day had a greater Barking Tendency and greater Human
263 and Object Fear than those exercised 4+ hours/day. Dogs exercised <1 hour/day were more

Excitable than others. Dogs exercised 1-2 hours/day were more likely to show Non-Owner Aggression than dogs exercised 2+ hours/day. Dogs exercised 1-2 hours/day were more likely to show Owner Aggression than dogs exercised 2-4 hours/day. Dogs exercised <1 or 2-4 hours/day showed more Separation Anxiety than those exercised 4+ hours/day. Dogs exercised 1+ hour/day had higher Trainability than dogs exercised <1 hour/day. Dogs exercised <1 hour/day were more likely to exhibit Unusual Behaviour than others, and dogs exercised <2 hours/day were more likely to exhibit these behaviours than dogs exercised 4+ hours/day.

3.4. Housing

Housing had an average effect size of 0.13. Dogs kept Indoor/Outdoor were more likely than Outdoor dogs to become Agitated when Ignored, although Indoor dogs were not significantly different from either group. Outdoor dogs showed less Excitability and Human and Object Fear than others, and were less likely to show Noise Fear than Indoor dogs. Dogs kept Indoor/Outdoor were more likely to show Non-Owner Aggression than other dogs.

3.5. Gender Status

Gender Status also had an average effect size of 0.13, and played a significant role in nine traits (Attention Seeking, Excitability, Human and Object Fear, Noise Fear, Non-Owner Aggression, Owner Aggression, Separation Anxiety, Trainability, and Unusual Behaviour) (Figure 3). Entire dogs showed more Attention Seeking and Excitability, and lower Human and Object Fear and Noise Fear, than Neutered Females. All Females showed

287 higher Non-Owner Aggression than Entire Males, and Entire Males showed higher Owner
288 Aggression than females. Entire Males showed higher Separation Anxiety than all other
289 categories. Entire Females had higher Trainability than Neutered Females. All Females
290 showed a higher incidence of Unusual Behaviour than Entire Males.

291

292 **3.6. Health, Age, BMI**

293 Health Status had an average effect size of 0.069, the lowest of the categorical
294 variables. Healthy dogs were more likely to exhibit Attention Seeking. Younger dogs were
295 more likely to show Human and Object Fear. Dogs with a lower BMI were more likely to
296 show Non-Owner Aggression.

297

298 **4. Discussion**

299 Given that the survey data by owners is subjective in nature, there is potential for
300 inaccuracy. The large sample size of this study may counter potential imprecision in
301 judgment. Furthermore, multiple questions targeting similar personality traits were
302 grouped, further reducing the role of individual inaccuracies. The survey data does not
303 allow us to directly investigate the causal relationship between variables. Therefore, these
304 results must be discussed in terms of associations and causal relationships can only be
305 hypothesized in most cases.

306

307 **4.1. Personality trait groupings**

308 The traits were grouped according to the PCA results and correlations. The most
309 distinct trait group was that for Trainability which appeared separately from the others in

310 the PCA (Figure 1). The questions from the Aggression section were consolidated into two
311 traits: Non-owner and Owner Aggression. Stranger, Dog, and Animal Aggression were
312 highly correlated with each other, but not with Owner Aggression. This indicates that there
313 are some fundamental differences between the expression of aggression towards human
314 owners and other people and animals in the Labrador Retriever. Previous studies with the
315 C-BARQ in a range of breeds have separated aggression into three categories, towards
316 owners, strangers, and dogs (Hsu and Serpell, 2003; Nagasawa *et al.*, 2011; Serpell and
317 Hsu, 2005). In a study comparing aggression in a large number of breeds, Labrador
318 Retrievers were shown to exhibit below-average levels of aggression towards owners, dogs
319 and strangers (Duffy *et al.*, 2008).

320

321 **4.2. Effects of genetics and lifestyle**

322 Genetic and experiential differences are known causes of personality variation in
323 dogs (Podberscek and Serpell, 1996). The variation in genetics and lifestyle was primarily
324 examined through Working Status, Coat Colour, and Exercise. Other sources of variation
325 were accounted for in the models, including Indoor/Outdoor Housing, Health Status and
326 BMI, but are not discussed in detail because of their limited impact in the statistical
327 analysis.

328 **4.2.1. Working Status**

329 Working Status was significantly associated with 10 out of 12 personality traits and
330 had the largest average effect sizes, making it the most influential factor. There are a
331 number of possible explanations for these effects: genetic differences between the Working
332 Status categories, difference in management and/or training between the categories or a

333 combination of the two influences. Additionally, differences in the effects of Working
334 Status may be exaggerated by the movement of dogs from one category to another if their
335 behaviour is inappropriate (i.e. a dog that does not perform well as a show dog becomes a
336 pet). We will refer to this phenomenon as ‘category shift’.

337 In terms of the genetic influence, our results may reflect a known division in this
338 breed. Labrador Retriever breeders and dog researchers recognize two types of Labrador
339 Retrievers, which are referred to as “conformation”-bred and “field” Labrador Retrievers in
340 the U.S. (http://en.wikipedia.org/wiki/Labrador_Retriever, accessed 22/11/13; Duffy *et al.*,
341 2008) or ‘show’ and ‘working’ strains in the UK (Craig, 2011). The former are generally
342 seen in dog shows while the latter are the type generally used as gundogs in the UK.
343 Genetic differences between the two strains may be the result of breeding animals for good
344 'performance' in either Showdog or Gundog roles, where performance in either category is
345 likely to be related to the dog's behaviour and personality. Gundogs are working dogs and
346 are expected to be responsive and obedient throughout long periods where activity
347 (fetching/retrieval) is interspersed with periods of inactivity (waiting for the next shoot to
348 take place), unlike Pets and Showdogs that are not relied upon to complete specific tasks.
349 The increased Attention Seeking, Fetching, and Trainability may relate to being attentive to
350 the commands of the handler, performing the retrieval task reliably and being easily trained
351 for all required tasks. Similarly the decreased Barking Tendency and Noise Fear of
352 Gundogs may be attributed to their requirement to be quiet whilst working and between
353 shoots, and unafraid of gunshot. Gundogs were also less likely to show Unusual
354 Behaviours, which are often labeled as 'stereotypies'. It has been shown that stereotypies are
355 negatively associated with stimulation and engagement (Sergiel *et al.*, 2012). The lowered

356 tendency to exhibit Unusual Behaviour in Gundogs may be due to the increased
357 environmental complexity that is associated with being a working dog, although category
358 shift could also explain the observed pattern.

359 Showdogs have to tolerate distracting environments with many people and animals
360 in close proximity and occasional physical handling by unfamiliar people, which may
361 explain their lower scores for Agitated when Ignored, Human and Object Fear, Noise Fear
362 and Non-owner aggression than Pets. The breeding of successful showdogs may have
363 promoted these personality traits.

364 However, previous training and experience may also explain some of these
365 differences in personality traits. The behavioural phenotype recorded in the questionnaire
366 may be influenced by the training or management regime of show and working dogs.
367 Whilst the differences in Trainability could be due to deliberate breeding strategies in
368 Gundogs, a Gundog will also undergo intensive training for its role, often by highly
369 experienced trainers. Therefore, the behavioural phenotype that was recorded in the
370 questionnaire may be influenced by this training, as has been shown in other studies
371 (Svartberg, 2002; Kutsumi et al., 2013). Similarly, Showdogs may have been become
372 desensitized to the multiple distractions of the dog show environment, and therefore react
373 less to these stimuli (Kubinyi *et al.*, 2009), and thus score lower in Excitability. Those that
374 did not adapt well to either activity may have been removed due to category shift.

375 It is likely that both genetic and training/experience influence the personality traits
376 documented by the questionnaire in this population of dogs. An experimental approach
377 would be required to disentangle these factors, in which behavioural outcomes are recorded

378 from Show and Gundog strains that are managed and trained in pet, show and gundog
379 environments.

380 **4.2.2. Coat Colour**

381 Chocolate Labrador Retrievers were different from Black and Yellow dogs for
382 several traits. Chocolate dogs had lower Noise Fear and Trainability, and exhibited more
383 Unusual Behaviour than yellow or black dogs. Additionally, Chocolate dogs were more
384 Agitated when Ignored, more Excitable, and had lower Fetching than black dogs. There are
385 two possible explanations for the differences. Firstly, the genes responsible for chocolate
386 coat colour could be genetically linked to the genes responsible for these personality traits,
387 which would make these characteristics likely to co-occur. The inheritance pattern of coat
388 colour has been studied in Labrador Retrievers and other breeds, and mutations in the
389 tyrosine related protein 1 gene (*TYRP1*) have been shown to be responsible for brown coat
390 colour in dogs (Templeton et al., 1977; Schmutz et al., 2002), however, genetic associations
391 between this gene and behavioural traits have yet to be investigated. Another explanation is
392 that in the attempts of dog breeders to produce a high frequency of Chocolate dogs, the
393 gene pool of dogs carrying the alleles for a Chocolate coat may have become somewhat
394 separated from that of the other Labrador retrievers. By chance, traits other than coat colour
395 may have higher frequencies in this gene pool, which could explain the differences in
396 personality. . Although the main difference was between Chocolate dogs and other dogs,
397 there were also some differences between Black and Yellow Labrador Retrievers (i.e.
398 Separation Anxiety).

399 **4.2.3. Exercise**

400 The level of exercise and stimulation a dog gets impacts its health and mental well-
401 being (Sergiel *et al.*, 2012). The amount of time the dogs were exercised was associated
402 with 8 of the 12 personality traits, and it had the second highest effect sizes. Associations
403 with personality traits could be due to the level of exercise directly influencing the
404 expression of certain behaviours, or it could be that dogs showing unwanted traits are not
405 taken out by owners as much as other dogs, for fear of an inability to control them leading
406 to embarrassment or harm, which we will call 'Behavioural Deterrence'.

407 Dogs exercised less had higher Excitability, lower Trainability, and exhibited more
408 Unusual Behaviour. The association between high levels of exercise and Trainability is
409 likely in part due to an increased exposure to training during activity. Dogs exercised more
410 showed less Unusual Behaviour, supporting the idea that higher exercise levels are good for
411 the mental health of the dogs. The increased stimulation from human interaction and time
412 outside in novel environments may help to reduce the incidence of stereotypies (Menor-
413 Campos *et al.*, 2011). This however is inconsistent with the results of Clark *et al.* (1997)
414 who found exercise had little effect on behaviour. The only behavioural difference they
415 found was an increase in barking among dogs exercised with a conspecific. However, the
416 periods of exercise used in their study were much shorter (20 minutes, 3 times a week) than
417 those reported here, suggesting that the quantity of exercise is important.

418 Dogs exercised more showed lower Non-Owner Aggression. This could be due to
419 increased exposure to unknown stimuli during prolonged activity. Frequent contact would
420 help familiarize the dog to strange people, animals and environments, and reduce the
421 likelihood of an aggressive response to novelty. This is supported by dogs exercised less
422 also showing higher Human and Object Fear, since fear and aggression have been shown to

423 be correlated in other studies (Duffy *et al.*, 2008). Behavioural Deterrence may also account
424 for these patterns, such that dogs showing non-owner aggression are not walked as often in
425 order to avoid awkward situations for the owner.

426 Dogs exercised less showed higher Barking Tendency and Owner Aggression. This
427 may again be due to Behavioural Deterrence, or they may be barking to attract the attention
428 of owners or as an outlet for boredom. This is supported by the finding that dogs exercised
429 less also showed more Attention Seeking and less Separation Anxiety. Boredom may lead
430 to frustration, manifested as aggression towards the people within the household.

431

432 **4.3. Gender and Age**

433 Gender status was significant in relation to 9 out of the 12 traits. Gender status is a
434 combination of the sex and neuter status of the dogs, and both of these may have had an
435 effect on their personality. Gender status has previously been shown to be associated with
436 personality traits in dogs (Wilsson and Sundgren, 1997; Svartberg, 2002), including
437 aggressiveness and boldness. Personality differences between the groups are likely to be
438 due to hormonal differences.

439 Entire Males and Entire Females differed significantly from Neutered Females for
440 four traits. Neutered Females showed less Attention Seeking and Excitability, and showed
441 more Human and Object Fear and Noise Fear than the Entire dogs. Neutered Males were in
442 the middle and not significantly different from either group for all four of these traits.
443 Excitability may be higher in Entire than Neutered Females due to differences in hormone
444 levels.

445 Females showed more Non-Owner Aggression than Entire Males, and Entire Males
446 showed more Owner Aggression and less Unusual Behaviour than all Females, and higher
447 Separation Anxiety than all groups. Higher aggression among Males has been reported
448 previously (Hart and Hart, 1985, Wilsson and Sundgren, 1997). Castration of male dogs has
449 been shown to reduce aggressive dominance to some extent, but not territorial aggression
450 (Hart and Eckstein, 1997). The latter category may contain components of the Non-owner
451 Aggression category from the present study. However, higher Non-Owner Aggression from
452 Females was not been reported in either of these studies. This may represent a form of
453 territorial aggression, but levels of all aggression from this breed were low in this study.

454 The age of the dog is one of the easier factors to understand. The age of the animal
455 relates to its past experience, and therefore has an influence on its personality (Stamps and
456 Groothuis, 2012). Older dogs showed significantly less Human and Object Fear. This is
457 possibly because experience has led them to discriminate between actual threats and
458 innocuous things. This is supported by older dogs showing less Separation Anxiety than
459 younger dogs, although this effect was not statistically significant. Older dogs have learned
460 their owners' routines, and are less concerned about prolonged absences.

461

462 **5. Conclusions**

463 This large-scale study of behavioural characteristics in Labrador Retrievers revealed
464 a number of associations between physical, lifestyle and management characteristics of the
465 dogs and personality traits. The explanatory factor with the largest overall effect was the
466 working status of the dog, where pets showed dispositions that are generally considered
467 less desirable than those of gundogs and showdogs. The mechanism by which working

468 status could affect behaviour is not yet known, but it is likely to involve both genetic and
469 environmental factors. Further research is required to disentangle these factors. There were
470 also significant associations between personality traits and other factors considered,
471 including coat colour, levels of exercise, age, sex, neuter status and housing.

472

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481

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583 Figure legends

584 Figure 1: Scatterplot of PC1 vs PC2 for C-BARQ responses. The different symbols refer to
585 the sections within C-BARQ (1: Training and obedience; 2: Aggression; 3: Fear and
586 anxiety; 4: Separation-related behavior; 5: Excitability; 6: Attachment and attention-
587 seeking; 7: Miscellaneous; Hsu & Serpell, 2003; <http://vetapps.vet.upenn.edu/cbarq/>).

588

589 Figure 2: Adjusted means for the three Working Status categories (Gundog, Pet, Showdog)
590 for the 12 personality traits described in the text (Agitated when Ignored, Attention
591 Seeking, Barking Tendency, Excitability, Fetching, Human and Object Fear, Noise Fear,
592 Non-Owner Aggression, Owner Aggression, Separation Anxiety, Trainability, and Unusual
593 Behaviour).

594

595 Figure 3: Adjusted means for the four gender/neuter status categories (EF=entire female;
596 EM=entire male; NF=neutered female; NM=neutered male) for the 12 personality traits
597 described in the text (Agitated when Ignored, Attention Seeking, Barking Tendency,
598 Excitability, Fetching, Human and Object Fear, Noise Fear, Non-Owner Aggression,
599 Owner Aggression, Separation Anxiety, Trainability, and Unusual Behaviour).

600